TITLE: Monitoring ecological responses to partial hydrologic reconnection of the Cache River T-114-R-1

NEED: Stream restoration projects have increased ten-fold since 1990, with nearly 10 billion dollars spent in the US to date (Bernhardt et al. 2005). Unfortunately, designs of many restoration projects often do not take into consideration basic ecological concepts (Palmer 2009). Others, although designed more prudently, have not been monitored for "ecological success" (Bernhardt et al. 2005, Palmer and Bernhardt 2006). Given the increasing demand for restoration projects, the tremendous resources allocated to them, and the need for quantitative measures of their effects on communities and ecosystem functioning, studies of restoration projects are critical for justifying and guiding future efforts.

The partial reconnection of the upper Cache River (UCR) and lower Cache River (LCR) segments provides the unique opportunity for a comprehensive assessment of ecological responses to a hydrologic restoration and can serve as a model for similar rivers and projects. Intensive monitoring of key physical and biological variables (selected based on prior studies in the system) before and after the partial reconnection will provide for a robust, quantitative assessment of ecological responses. Further, prior projects on the Cache have generated long term datasets on dissolved oxygen and aquatic invertebrates that will further strengthen assessments of responses to the reconnection. This research will build on prior research and monitoring efforts, many of which were funded with SWG grants, and guide future management and restoration activities in the Cache and serve as a model for other systems. Without this information, there will be no way of assessing the overall success, or lack thereof, of the reconnection, or how populations of Species in Greatest Conservation Need respond.

Several restoration projects have been carried out in the Cache River basin. These include construction of weirs to stabilize the channel. These weirs also act as "hotspots" of aquatic insect production (Walther and Whiles 2008), and potentially provide important food and habitat for fish. Reconnecting the upper and lower Cache River channels, which were separated to facilitate drainage of agricultural lands, has been proposed as a restoration project to address water quality issues and ecological integrity in the lower Cache. Reconnection would increase flow in the Lower Cache River and influence oxygen dynamics (e.g., Garvey et al. 2007), presumably resulting in positive responses by aquatic communities, but the pros and cons of reconnection are difficult to assess without quantitative information on potential ecological responses.

PURPOSE AND OBJECTIVES: The primary purpose of this project is to assess ecological responses, from individual species to ecosystem function, to partial hydrologic reconnection of the upper and lower segments of the Cache River. This information can then guide further management of the system and well as inform similar future projects and provide justification for further restoration efforts. Specific objectives include:

1) Quantify changes in the physical template of the LCR, including flow velocity, dissolved oxygen, temperature, and light penetration from pre- to post-reconnection conditions.

2) Assess organic matter pools and associated energy flow dynamics, including organic sediments, sediment respiration, primary production, system metabolism, and duckweed cover, before and after the partial reconnection.

3) Quantify changes in in-stream invertebrate communities (abundance, biomass, community structure), adult insect emergence (biomass and community structure), and fish communities (abundance, biomass, and community structure) from pre- to post-reconnection conditions.

Collectively, these variables will reflect responses ranging from the population (e.g., responses of Species in Greatest Conservation Need) to ecosystem function (e.g., ecosystem metabolism) levels.

EXPECTED RESULTS AND BENEFITS: Given the extensive existing (pre-reconnection) data sets on Cache River physicochemical parameters and biological communities from prior SWG projects and related studies, this project will provide the most comprehensive assessment of ecological responses to a river flow restoration to date. As noted above, lack of detailed pre- and post-restoration studies has plagued restoration efforts for decades because it is difficult to justify further projects, assess and modify restoration methods, and develop effective post-restoration management plans without this information (Bernhardt et al. 2005, Palmer and Bernhardt 2006). This project will serve as a model for hydrologic river restoration efforts and associated monitoring activities.

Importance to Species in Greatest Conservation Need in Illinois. The proposed project will assess responses of numerous Species in Greatest Conservation Need in Illinois. We will monitor potential direct impacts on numerous species that live in the Cache River and its tributaries including the Banded Pygmy Sunfish, Bantam Sunfish, Bigeye Shiner, Blacktail Shiner, Cypress Darter, Cypress Minnow, Flier, and Fringed Darter; these species are all present in the drainage and will likely benefit from the reconnection. Stream invertebrates in Greatest Conservation Need, including the Variegated False Water Penny Beetle, Illinois Crayfish, Shrimp Crayfish, and Bousfield's Amphipod, may also be influenced by the reconnection. Provided they are present in the system during the study, their populations will be monitored through regular invertebrate sampling.

In addition to direct influences, monitoring how the reconnection influences aquatic insect emergences from the river channel will allow for assessment of indirect influences on numerous riparian Species in Greatest Conservation Need. We know from prior studies that riparian insectivores such as birds respond positively to insect emergences from the Cache, particularly during periods when terrestrial insect prey are relatively scarce in riparian habitats (Heinrich et al. 2014). Sampling during this study will provide quantitative information on how reconnection influences the amount, quality, and timing of aquatic insect prey for riparian insectivore species such as the Bird-voiced Treefrog, Pickerel Frog, Indiana Bat, Southeastern Myotis, Eastern Small-footed Myotis, Gray Bat, and Rafinesque's Big-eared Bat, as well as numerous riparian forest birds including the Acadian Flycatcher, Bell's Vireo, Bay Breasted Warbler, Black-billed Cuckoo, Blue-winged Warbler, Cerulean Warbler, Chuck-Will's Widow, Common Nighthawk, Connecticut Warbler, Eastern Whip-poor-will, Eastern Towhee, Golden-winged Warbler,

Kentucky Warbler, Marxh Wren, Ovenbird, Prothonotary Warbler, Willow Flycatcher, Wood Thrush, Worm-eating Warbler, Yellow-billed cuckoo, and yellow-breasted chat.

APPROACH: Building on existing long-term datasets on dissolved oxygen, benthic sediments, and invertebrate communities (e.g., Heinrich et al. 2014, Scholl et al. 2016, Bauman et al. submitted), we will measure a suite of physical (flow, continuous dissolved oxygen, temperature, light penetration) and biological (organic sediments, sediment respiration, primary production, system metabolism, duckweed cover; abundance, biomass, and diversity of aquatic invertebrates and fishes, biomass and community structure of emerging adult aquatic insects) variables at 4 sites located above the reconnection site (UCR) and 4 sites below the reconnection (LCR) for one year prior to reconnection and two years following reconnection. Site selection and sampling periods will follow a Before-After-Control-Impact design (BACI) (Hurlbert 1984).

Benthic invertebrates, aquatic insect adult emergence, benthic organic matter resources, and duckweed cover will be sampled monthly when water levels allow access, using methods we have developed in the Cache and successfully published (Walther and Whiles 2008, Heinrich et al. 2014, Scholl et al. 2016). Datalogging dissolved oxygen meters and light meters will be deployed at sites seasonally during stable flow periods. Flow velocities will be measured weekly during baseflow conditions. Fish communities will be sampled seasonally, when water levels permit, using a combination of seines and a backpack electroshocker.

Sediment organic content and respiration will be measured in the laboratory using standard analytical procedures (Wallace et al. 2006). Invertebrates will be identified to the lowest practical taxonomic level (usually genus) and measured (total body length) so that biomass can be estimated using length-mass relationships from Benke et al. (1999).

USEFUL LIFE: N/A

GEOGRAPHIC LOCATION: The Cache River watershed lies at the confluence of four major physiographic provinces in southernmost Illinois and harbors high aquatic and riparian species diversity (McNab and Avers 1994). The Cache watershed is also recognized as one of the few regions in the US containing wetlands of international significance, which include critical breeding and overwintering grounds for migratory birds. The Cache supports 44% of the native fish species and 60% of native mussels species in Illinois, as well as 34 crustacean and >340 macroinvertebrate species (IDNR 1997). However, the Cache has experienced impaired water quality that threatens this biodiversity, and much of this is related to human modifications to the landscape and channel (IEPA 2008).

Four study sites will be established on the UCR and four on the LCR in Johnson, Massac, and Pulaski counties, IL. Physical and biological monitoring (see objectives and approach sections) will take place at each of the eight study sites.

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PROGRAM INCOME: N/A

Budget Catagories	Federal Funds	Non-Federal Funds	Total
Salaries and Wages			
Administrative/Professional	$51,927.00	$38,132.00	$90,059.00
Academic / Graduate Hourly Wages	$92,522.00		$92,522.00
Other Title			$0.00
Tuition Remission			$0.00
Fringe Benefits			
Administrative/Professional	$34,081.00	$15,216.00	$49,297.00
Academic / Graduate Hourly Wages	$1,868.00		$1,868.00
Other Title			$0.00
Travel			
In-State			
Meals / Per Diem			$0.00
Lodging			$0.00
Mileage			$0.00
Out-of-State			
Meals / Per Diem	$800.00		$800.00
Lodging	$2,000.00		$2,000.00
Mileage	$2,500.00		$2,500.00
International			
Meals / Per Diem			$0.00
Lodging			$0.00
Mileage			$0.00
Equipment			
			$0.00
Materials and Supplies			
field and lab expendables	$10,000.00		$10,000.00
Contractual Services			
truck rental	$12,000.00		$12,000.00
nutrient analyses	$9,000.00		$9,000.00
Other			
			$0.00
Total Direct Costs	$216,698.00	$53,348.00	$270,046.00
Modified Total Direct Cost (MTDC)	$216,698.00	$53,348.00	$270,046.00
Indirect Rate of 20%	$42,208.00		$42,208.00
Indirect Rate of 47.5 %		$28,027.00	$28,027.00
Unrecovered Indirect Rate (20% vs 47.5% MTDC)		$58,036.00	$58,036.00
Overmatch			$0.00
Total Project Costs	$258,906.00	$139,411.00	$398,317.00
Percentage of Total Project Cost	65.00%	35.00%	100.00%

BUDGET NARRATIVE:

Salaries and Wages:

This project will be extremely labor intensive and thus most requested funds will be used to support a technician for 50% of their annual salary for the 3 years (currently $16,800 for ½ annual salary and assuming 3% raises per year for a total of $51,927 for 3 years). PI Whiles will dedicate 1 month per year salary match (currently $12,337, assuming 3% raise per year).

Funds are requested to support a doctoral student for 3 years, starting at $19,257 for year 1 and assuming 3% raise per year.

Funds are requested to support two undergraduate student workers for ~15 hours per week most of each calendar year (= ~$5,500 per year for each x 2 = $11,000).

Fringe and benefits:

Retirement and insurance for the technician and PI are 54.74% at SIU.

A primary care fee is included for the graduate student at $602 for year 1 and increasing by $20 each year thereafter.

Travel:

Funds are requested for two people to attend the Society for Freshwater Science meeting and present results of the study in year 2 ($1,000 airline tickets, $800 lodging, $320 per diem), and three people to attend a meeting and present in year 3 ($1500 airline tickets, $1200 lodging, $480 per diem). The SFS meetings will be in Raleigh, NC from June 4-8 in Year 2 and TBA in year 3.

Equipment:

Equipment needed to complete this project is already in place.

Materials and supplies:

Expendables needed to complete this project include replacement probes and batteries for datalogging sondes, preservatives, reagents, vials, sample bottles, field notebooks, glass fiber and membrane filters, replacement fiber optics for microscope lights, field notebooks, forceps, picking trays, sieves, replacement nets for samplers, filtration pumps, emergence trap construction supplies, and microscope slides. Much of this will be purchased in year 1 ($5,000), and then replenished and replaced as needed during years 2 ($3,000) and 3 ($2,000).

Contractual services:

This project will require a dedicated, year round 4 wheel drive field vehicle available for sampling and monitoring activities. The vehicle will be leased from SIU at a rate of $3,500 per year, +$500 per year for maintenance costs with SIU Travel Services.

Funds are requested for analyzing nutrients in water and nutrients and organic matter in sediments. Prices per sample range from $5 to $20, depending on water or sediments and type of analyses. Total costs for analytical services are estimated at $3,000 per year based on our prior projects in the Cache.

Other:

The federally negotiated indirect rate at SIU is currently 47.5%. Indirect on the SIU match is calculated with this rate and unrecovered indirect is calculated as the difference between 47.5% and 20% of the MTDC federal funds.

MULTIPURPOSE PROJECTS: N/A

RELATIONSHIPS WITH OTHER GRANTS: Much of the baseline, pre-connection data for this project were collected with two prior SWG grants awarded to Whiles and colleagues in 2007 (Project Number: T-51-D-1; Demonstrating the Benefits of In-stream Restoration) and 2010 (T-66-R-001; Demonstrating the benefits of Stream Restoration to Aquatic Communities in the Cache River Basin). These two projects resulted in 3 completed MS theses, 3 peer-reviewed publications, and two additional publications currently in review. These theses and publications include comprehensive datasets on aquatic invertebrate communities, emergent insect production, fish communities, and dissolved oxygen, organic matter pools, and sediment respiration in the Cache, and will provide an important foundation for quantitatively assessing ecological responses to the partial reconnection.

We will sample focal physical and biological variables (see above objectives) for at least one year prior to the reconnection. However, the hydrology of the Cache River is extremely variable over both short term and annual scales, and this hydrologic variability profoundly influences other elements of the physical template and the biota (Bauman et al., submitted). The long-term, pre-restoration datasets from our prior studies, along with pre-reconnection sampling during this project, will allow for more robust assessments of ecological responses by allowing us to statistically account for and incorporate variability in our analyses.

TIMELINE:

Pre-reconnection field sampling: Aug. 2016 – 2017 (monthly invertebrates and organic matter; seasonal dissolved oxygen, metabolism, and fish communities)

Post reconnection field sampling: Sept. 2017 – July 2019 (monthly invertebrates and organic matter; seasonal dissolved oxygen, metabolism, and fish communities)

Sample processing and data analyses will take place throughout the duration of the project after the first sampling event in August 2016. Annual project reports will be submitted in Aug. 2017,

2018, and a final report will be submitted in August 2019. A dissertation based on this project will be completed by autumn 2020.

The project is designed for one year of pre- reconnection sampling of all physical and biological metrics (see approach section). This pre-sampling will also build on existing datasets generated from our prior work on the same sections of the river from 2005 – 2015 (Walther and Whiles 2008, Heinrich et al. 2014, Scholl et al. 2016, Baumann et al., Submitted).

The schedule is realistic and attainable with the resources that are already in place, the resources requested in this proposal, and our extensive experience working on this system.

GENERAL:

(i) **Substantial in Character and Design**

The project statement describes a need consistent with the Wildlife Restoration Act; states a purpose and sets objectives, both of which are based on the need; uses a planned approach, appropriate procedures, and research and is cost effective.

(ii) **Compliance**

The IDNR will use its CERP (Comprehensive Environmental Review Process) as a tool to aid the Department in meeting NEPA compliance for the project outlined under this grant proposal. It is the Department's policy to require CERP applications for all land disturbing activities unless those activities are covered by CERP exemptions.
All planned activities will also be in compliance with the Endangered Species Act. All determinations and documentation will be in accordance with the current established U.S. Fish and Wildlife Service protocols for section 7.
All planned activities will be in compliance with the National Historic Preservation Act and the Council on Historic Preservation Act. All determinations and documentation will be in accordance with the terms of the Programmatic Agreement, as amended, effective September 23, 2002.
When applicable, those planned activities which involve a floodplain and/or jurisdiction wetlands will be done in accordance with Presidential Executive Orders 11988 and 11990.
When applicable, those planned activities which involve programs and/or site improvements will be done in accordance with Section 504 of the Rehabilitation Act and the Americans with Disabilities Act.
When applicable, those planned activities which involve the use of pesticides, herbicides or other comparable chemicals will be done in accordance with current state and federal regulations to assure the safe and legal application of those chemicals. All chemicals will be applied in accordance with the manufacturers label instructions. All persons applying chemicals will be licensed by the Illinois Department of Agriculture as a chemical operator along with a licensed applicator, in accordance with Illinois state law.

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